Applicant: Shih et al.
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30. (Amended) The system of claim 27, wherein the modeling application modifies the <u>voxel-based</u> virtual object based on the position of the virtual tool.

31. (Amended) The system of claim 27, wherein the modeling application calculates an interaction force among the constraint geometry, the <u>voxel-based</u> virtual object, and the virtual tool in response to determining the position of the virtual tool.

32. (Amended) The system of claim 27, further comprising a modification mode for the virtual tool selected by the user, and the modeling application modifies the <u>voxel-based</u> virtual object in response to the modification mode and the position of the virtual tool.

Clean Copy of Pending Claims

in accordance with 37 C.F.R. 1.121(c)

1   1. (Amended) A method for modifying a virtual object in a haptic virtual environment,

2   comprising:

3   determining a virtual tool comprising a plurality of discrete points for use by the user in

4   the haptic virtual environment;

5   selecting a modification mode other than a surface deformation for the virtual tool;

6   sensing a location of a user in real space;

7   determining locations of the plurality of discrete points of the virtual tool relative to a

8   location of the virtual object;

9   calculating an interaction force between the virtual tool and the virtual object based on

10 the locations of the plurality of discrete points of the virtual tool and the location of the virtual

11 object;

12   producing a modified virtual object by modifying the virtual object based on the

13 modification mode, the locations of the plurality of discrete points of the virtual tool, and the

14 location of the virtual object; and

15   outputting the modified virtual object.

1   2. The method of claim 1, further comprising the steps of

2   determining a virtual surface for the virtual object; and

3   determining a position and an orientation of the virtual tool by determining the locations

4   of the plurality of discrete points relative to the virtual surface of the virtual object.

1   3. The method of claim 2, wherein the step of determining the virtual surface comprises

2   determining a virtual isosurface for the virtual object.

1   4. The method of claim 1, wherein the virtual object is a volumetric representation.

1   5. The method of claim 4, wherein the volumetric representation comprises voxels comprising

2   density values.

1   6. (Amended) The method of claim 1, wherein the step of selecting a modification mode for the

2   virtual tool comprises selecting at least one of a material removal mode, a material addition

3   mode, a smoothing mode, a mirroring mode, and a 3-D sketch mode.

1   7. The method of claim 1, further comprising the step of determining at least one virtual

2   constraint for the movement of the virtual tool.

1   8. The method of claim 7, wherein the step of determining at least one virtual constraint for the

2   movement of the virtual tool comprises determining at least one of a point, curve and surface

3   constraint for the movement of the virtual tool.

1   9. The method of claim 1, further comprising the step of exporting the modified virtual object.

1   10. (Amended) A system for modifying a virtual object by a user in a haptic virtual environment,

2   the system comprising:

3   a virtual tool comprising a plurality of discrete points for use by the user in the haptic

4   virtual environment, wherein the user selects a modification mode for the virtual tool other than a

5   surface deformation;

6   a haptic interface device, wherein the haptic interface device senses a location of the user

7   in real space;

8   a modeling application in communication with the haptic interface device, the virtual

9   object, and the virtual tool, wherein the modeling application determines locations of the

10   plurality of discrete points of the virtual tool relative to a location of the virtual object; calculates

11   an interaction force between the virtual tool and the virtual object based on the locations of the

12   plurality of discrete points of the virtual tool and the location of the virtual object; produces a

13   modified virtual object by modifying the virtual object based on the modification mode; the

14   locations of the plurality of discrete points of the virtual tool, and the location of the virtual

15   object; and outputs the modified virtual object.

1   11. The system of claim 10, further comprising

2   the virtual object comprising a virtual surface; and

3   the virtual tool comprising a position and an orientation, wherein the modeling

4   application determines the position of the virtual tool and the orientation of the virtual tool by

5   determining the locations of the plurality of discrete points relative to the virtual surface of the

6   virtual object.

1   12. The system of claim 11, wherein the virtual surface of the virtual object is a virtual

2   isosurface.

1   13. The system of claim 10, wherein the virtual object is a volumetric representation.

1   14. The system of claim 13, wherein the volumetric representation comprises voxels comprising

2   density values.

1   15. (Amended) The system of claim 10, wherein the modification mode is a selected one of a

2   material removal mode, a material addition mode, a smoothing mode, a mirroring mode, and a 3-

3   D sketch mode.

1   16. The system of claim 10, wherein the user determines at least one virtual constraint for a

2   movement of the virtual tool.

1   17. The system of claim 16, wherein the at least one virtual constraint for the movement of the

2   virtual tool is at least one of a point, curve and surface constraint.

1   18. The system of claim 10, wherein the modeling application exports the modified virtual

2   object.

1   19. (Amended) A method for interfacing with a voxel-based virtual object in a haptic virtual

2   environment, comprising:

3   generating a voxel-based virtual object comprising a virtual surface in the haptic virtual

4   environment;

5   setting a constraint geometry in the haptic virtual environment;

6   determining a virtual tool for use by the user in the haptic virtual environment;

7   sensing a location of a user in real space;

8   determining a haptic interface location in the haptic virtual environment in response to

9   the location of the user in real space;

10   determining a position of the virtual tool in the haptic virtual environment in comparison

11   to the haptic interface location and the location of the virtual surface and the constraint geometry;

12   constraining an action of the virtual tool based on (i) the constraint geometry, (ii) the

13   virtual surface, (iii) the position of the virtual tool, and (iv) the haptic interface location.

1   20. The method of claim 19, wherein the step of setting a constraint geometry comprises setting

2   at least one of a constraint point, constraint curve, and a constraint surface.

1   21. The method of claim 19, wherein the step of determining the position of the virtual tool

2   further comprises moving the position of the virtual tool to coincide with the haptic interface

3   location.

1   22. (Amended) The method of claim 19, further comprising the step of modifying the voxel-

2   based virtual object based on the position of the virtual tool.

1   23. (Amended) The method of claim 19, further comprising calculating an interaction force

2   among the constraint geometry, the voxel-based virtual object, and the virtual tool in response to

3   the step of determining the position of the virtual tool.

1   24. (Amended) The method of claim 19, further comprising the steps of selecting a modification

2   mode for the virtual tool, and modifying the voxel-based virtual object in response to the

3   modification mode and the position of the virtual tool.

1   25. The method of claim 19, wherein the step of constraining the action of the virtual tool

2   comprises constraining the translation of the virtual tool.

1   26. The method of claim 19, wherein the step of constraining the action of the virtual tool

2   comprises constraining the rotation of the virtual tool.

1   27. (Amended) A system for interfacing with a voxel-based virtual object in a haptic virtual

2   environment, the system comprising:

3   a voxel-based virtual object comprising a virtual surface;

4   a virtual tool for use by the user in the haptic virtual environment;

5   a constraint geometry limiting the movement of the virtual tool in the haptic virtual

6   environment;

7   a haptic interface device, wherein the haptic interface device senses a position of the user

8   in real space;

9   a modeling application in communication with the haptic interface device, the voxel-

10   based virtual object, and the virtual tool, wherein the modeling application determines a haptic

11   interface location in the haptic virtual environment in response to the location of the user in real

12   space; determines a position of the virtual tool in the haptic virtual environment in comparison to

13   the haptic interface location, and the location of the virtual surface and the constraint geometry;

14   and constraining an action of the virtual tool based on (i) the constraint geometry, (ii) the virtual

15   surface, and (iii) the position of the virtual tool, and (iv) the haptic interface location.

1   28. The system of claim 27, wherein the constraint geometry is at least one of a constraint point,

2   constraint curve, and a constraint surface.

1   29. The system of claim 27, wherein the modeling application determines the position of the

2   virtual tool by moving the position of the virtual tool to coincide with the haptic interface

3   location.

1   30. (Amended) The system of claim 27, wherein the modeling application modifies the voxel-

2   based virtual object based on the position of the virtual tool.

1   31. (Amended) The system of claim 27, wherein the modeling application calculates an

2   interaction force among the constraint geometry, the voxel-based virtual object, and the virtual

3   tool in response to determining the position of the virtual tool.

1   32. (Amended)The system of claim 27, further comprising a modification mode for the virtual

2   tool selected by the user, and the modeling application modifies the voxel-based virtual object in

3   response to the modification mode and the position of the virtual tool.

1   33. The system of claim 27, wherein the action of the virtual tool comprises a translation of the

2   virtual tool.

1   34. The system of claim 27, wherein the action of the virtual tool comprises a rotation of the

2   virtual tool.

1   35. (New) The method of claim 1, wherein the virtual object comprises a voxel-based virtual

2   object.

1   36. (New) The system of claim 10 wherein the virtual object comprises a voxel-based virtual

2   object.